(NASA TMX51006)

MULTIPLE SCATTERING OF LOW ENERGY ALPHA PARTICLES IN A GAS

By G. Allen, R. Webeler, and S. Barile

Lewis Flight Propulsion Laboratory
National Advisory Committee for Aeronautics
Cleveland, Ohio

NASA TECHNICAL PAPER
CLEARED FOR PUBLIC RELEASE
DATE 2-16-62

Feb. 16, 1956

The results of the theories of the multiple scattering of charged particles can be expressed in terms of the angle between adjacent chords on the projection of the path of the particle. We will call this angle ω. The distribution function for the number of particles for which this angle lies between ω and $\omega + d\omega$ is given by an expression of the form shown in the first slide.

N63-85889
Code 5

$$(1)\quad dG(\omega) = (2\pi\sigma_\omega^2)^{-1/2} \exp -\left(\frac{\omega^2}{2\sigma_\omega^2}\right) d\omega + dG'(\omega)$$

where σ_ω^2 is the variance of the gaussian part of the distribution and where $dG'(\omega)$ is the large angle "tail" of the distribution.

In the present experiment, we undertook to determine σ_ω and the magnitude of the scattering angle ω_c at which the "tail" of the distribution becomes dominant.

For this purpose, alpha particles from a polonium source were slowed down and allowed to enter a cloud chamber containing a mixture of hydrogen, water, and ethyl alcohol at partial pressures of 12.25 centimeters, 1.5 centimeters, and 2.25 centimeters, respectively, during the sensitive time of the chamber. Eighty-four sharp tracks which showed no sharp bends due to single scattering were selected for study. In order to determine the variation of the magnitude of the scattering angle with energy, it is necessary to group the data in such a manner that the scattering angles in a given set all correspond to particles having the same energy.

Accordingly, we started at the terminus of the tracks (where the particles have essentially zero energy) and measured the angles between successive chords of three mm length.

The experimental error was determined in a similar manner: We measured the angles between successive 3 mm chords of a circle and a straight line. The diameter of the circle was 3.4 centimeters so that the angle between successive 3 mm chords on its circumference was 10°. Since the average magnitude of only about 13 percent of the scattering angles was 10°, the standard deviations of 2° and 3° obtained respectively for the straight line and the circle constitute effective limits for the experimental error. All of the angle measurements both for the errors determination and on the actual tracks were made independently by two of us.

If the effect of straggling is neglected, the distance to the terminus of a track determines the energy of the alpha particle at any point, so that the energies at the first three intersections of the chords are about 18, 45, and 85 kev. The next slide shows the frequency distributions, in intervals of 6° for the magnitude of the scattering angles. As can be seen, the number of measurements was insufficient to remove the effects of chance from the large angle portion of the distributions.

In order to reduce the influence which these effects have on any attempts to determine the form of the distribution, the data were plotted on normal probability graph paper. (Next slide)

This paper has the property that if the cumulative normal distribution function $\frac{1}{\sqrt{2\pi\sigma^2}} \int_{-\infty}^{x} e^{-\frac{(x-\mu)^2}{2\sigma^2}} dx$ is plotted as abscissa against the variate x as ordinate, the resulting set of points will be a straight

line which passes through the points (50 percent, μ) and (84.13 percent, $\mu + \sigma$) so that the mean and the standard deviation are determined. The ordinate of a point on this graph is the measured value of the scattering angles and the abscissa is the cumulative frequency of the angles in the distribution which have values equal to or less than the corresponding ordinate, here expressed as a percent of the total number of measurements. We see that for particles having an energy of 85 kev. the distribution is fairly well represented by a gaussian with a σ of 3° for scattering angles having magnitudes up to about 4°; for 45 kev. alpha particles, the σ of the gaussian part of the distribution is 4.5 and the "tail" of the distribution begins to dominate at scattering angles with magnitudes between 6° and 8°; while at 18 kev., the σ is about 7° and the "tail" does not show up till about 10°. The standard deviations obtained in this way include the experimental error. The average magnitudes of the angles were 2.5°, 4°, and 7.9°, respectively for the 85 kev., 45 kev. and 18 kev. alpha particles so respective corrections for standard deviations due to experimental error of 2°, 2.5° and 3° were applied to the total standard deviations, σ_T. The standard deviations due to scattering are then 2.2°, 3.7° and 6.3° respectively for the 85 kev., 45 kev. and 18 kev. particles. These results are summarized in the next slide.